Machinery/Automation

Vapor-Compression Heat Pumps for Operation Aboard Spacecraft

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Vapor-compression heat pumps (including both refrigerators and heat pumps) of a proposed type would be capable of operating in microgravity and would be safe to use in enclosed environments like those of spacecraft. The designs of these pumps would incorporate modifications of, and additions to, vapor-compression cycles of heat pumps now used in normal Earth gravitation, in order to ensure efficiency and reliability during all phases of operation, including startup, shutdown, nominal continuous operation, and peak operation. Features of such a design might include any or all of the following:

(1) Configuring the compressor, condenser, evaporator, valves, capillary tubes (if any), and controls to function in microgravitation;
(2) Selection of a working fluid that satisfies thermodynamic requirements and is safe to use in a closed crew compartment;
(3) Incorporation of a solenoid valve and/or a check valve to prevent influx of liquid to the compressor upon startup (such influx could damage the compressor);
(4) Use of a diode heat pipe between the cold volume and the evaporator to limit the influx of liquid to the compressor upon startup; and
(5) Use of a heated block to vaporize any liquid that arrives at the compressor inlet.

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Multistage Electrophoretic Separators

Separations can be performed in preparative quantities and can be automated.

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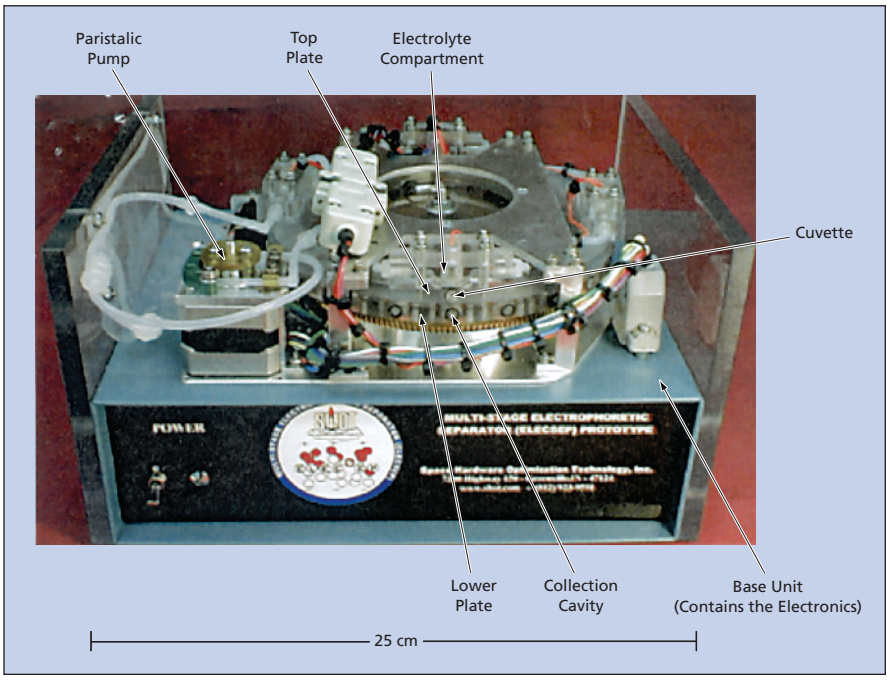
A multistage electrophoresis apparatus has been invented for use in the separation of cells, protein molecules, and other particles and solutes in concentrated aqueous solutions and suspensions. The design exploits free electrophoresis but overcomes the deficiencies of prior free-electrophoretic separators by incorporating a combination of published advances in mathematical modeling of convection, sedimentation, electro-osmotic flow, and the sedimentation and aggregation of droplets. In comparison with other electrophoretic separators, these apparatuses are easier to use and are better suited to separation in relatively large quantities characterized in the art as preparative (in contradistinction to smaller quantities characterized in the art as analytical).

In a multistage electrophoretic separator according to the invention, an applied vertical steady electric field draws the electrically charged particles of interest from within a cuvette to within a collection cavity that has been moved into position of the cuvette. There are multiple collection cavities arranged in a circle; each is aligned with the cuvette for a prescribed short time. The multistage, short-migration-path character of the invention solves, possibly for the first time, the fluid-instability problems associated with free electrophoresis.

The figure shows a prototype multistage electrophoretic separator that includes four sample stations and five collection stages per sample. At each sample station, an aqueous solution or



This **Multistage Electrophoretic Separator** contains four sample stations, of which one faces front in this view.